TITLE: Characteristic Extraction of Face Using DWT and Recognition Based on Neural Networks

Characteristic Extraction of Face using DWT and Recognition Based on Neural Networks

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ABSTRACT

In this paper, we suggests how to segment the face when there is the man under complex environment, extracts the features from segmented the image and proposes a effective recognition system using the discrete wavelet transform (DWT). This algorithm is proposed by following processes. First, two gray-level images is captured with 256 level of the size of 256× 256 in constant illumination. We use a Gaussian filter to remove noise of input image and get a differential image between background and input image. Second, a mask is made from erosion and dilation process after binary of the differential image. Third, facial image is divided by projecting the mask into input image. Most characteristic information of human face is in eyebrow, eyes, nose and mouth. In the reason, the facial characteristic are detected after selecting local area including this area. Forth, detecting the characteristic of segmented face image, edge is detected with Sobel operator. Then, eye area and the center of face are searched by using horizontal and vertical components of edge. Characteristic area consists of eyes, a nose, a mouth, eye brows and cheeks, is detected by searching the edge of the image. Finally, characteristic vectors are extracted from performing DWT of this characteristic area and are normalized it between +1 and -1. Normalized vectors is used with input vector of neural network. Simulation results show recognition rate of 100 % about learned image and 92% about test image.

Keyword : Mask, Differential image, Discrete wavelet transform, Neural network, Face recognition

1. INTRODUCTION

Edge image is mainly used to discriminate whether there is face or not in the image. Sakai applied oval mask to edge map extracted from input image, set the approximate head area, checked the edge image of eyes and mouth within the head area and then extracted the final head area[1]. This method has the weakness that it is influenced greatly by the direction of lighting. Kelly also produced the downward image interpretation method that extracts the outline of head and body automatically from input image and continuously extract the location of eyes, nose and mouth[2]. Craw and others proposed the method extracting head area using mask of hierarchical size in a given image[3]. Using the outline of head

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which is composed of edge image, Govindaraju searched the face in the complex background image[4]. Sirohey segmented the face by using edge image and brightness image which are extracted with Canny edge searcher in the image with background[5]. This method showed the precision of about 80% about 48 images without any restriction. In case of recognizing segmented images, feature extraction methods consists of local feature extraction and global feature extraction algorithm.[6] Feature location detection methods include the method by geometrical symmetry, method using correlation of feature templates like eyes, nose and mouth and image, method detecting face to search face candidate edges with snakelets, method detecting features of face with self-organizing feature map and method extracting the feature from frequency domain like FFT, DCT. After extracting the features, generally, Euclidean distance and neural network is used to recognize the face. While the former has the strength that system implementation is easy, it has also weakness that recognition rate is lowered when there are a lot of data. In case of performing pattern recognition with the latter, Input images are converted into spatial or frequency domain. Then, feature parameters of the image are extracted and it is used with input vectors of neural network. This method has the properties that the number of nodes and connection lines can be reduced and system implementation are easy[7]. In this paper, we propose that use differential image to obtain a mask and segment the face using a mask. Also, we define the characteristic areas of face to reduce the computational complexity in extracting the characteristic. And we extract the exact characteristic vectors using discrete wavelet conversion. This method reduces the number of characteristic vectors and decreases the required learning data in learning with neural network. In section 2, we describe face segmentation algorithm based on differential image. Section 3 describes face recognition algorithm based on wavelet. Section 4 describe simulation results. Conclusions are given in section 5.

2. FACE SEGMENTATION ALGORITHM BASED ON DIFFERENTIAL IMAGE

2.1 Face Segmentation Using Differential Image and Mask

The face is segmented by applying differential images in regular illumination condition. Image is obtained with gray scale 256 level of the size of 256×256 and the noise in the image is rejected by Gaussian filtering. And since the pixel value outside the face in input image including the face is not identical with that of background image which doesn't include the face exactly in obtaining the difference of input images including background image and face, threshold is given as shown in the following Expression (1) and the pixel value of the image obtained with the same camera can get the desired image though it is changed a little.

If $|Image1(x,y) - Image\ 2(x,y)| < threshold$

Then $Differ\_Image(x,y) = 0$

Else $Differ\_Image(x,y) = |Image1(s,y) - Image2(x,y)|$ (1)

For, *Image1*, *Image2* : input image, *Differ_Image* : differential image

The noise occurred by the change of illumination and the reflection of light occupies small area in the image because of low frequency of noise and it makes binary differential image and erodes the image. Eroded binary image should be dilated to the size of face image. Then pixel value is examined, mask is made, it is projected on the original image with the face and

the face is segmented in the background. Fig. 1 shows the flow chart to segment the face.

2.2 Feature Detection of Face

Most feature information of human face is in eyebrow, eyes, nose, mouth and cheek. So the face features are detected after selecting local area including this area. For the feature detection of segmented face image, edge is detected with sobel operator and eye area and the center of face are searched by using horizontal and vertical components of edge.

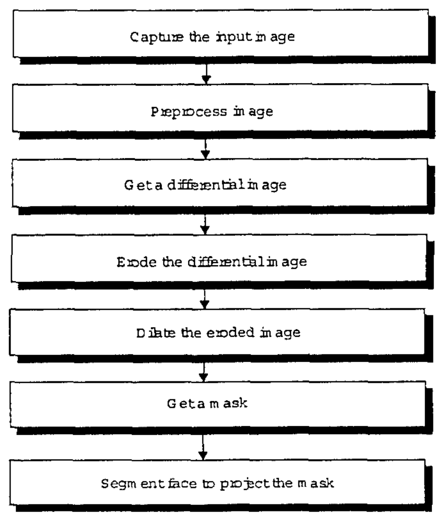


Fig. 1 Flow chart for facial image segmentation

Further since the size of human faces in regular distance is similar, square area should be defined to include eyebrow, eyes, nose and cheek like Fig. 2 and it is considered as the feature area of face recognition. After the conversion of discrete wavelet of extracted feature areas, extract the features. a(a=c+e+f) in Fig. 3 indicates horizontal distance of characteristic area and b the vertical distance.

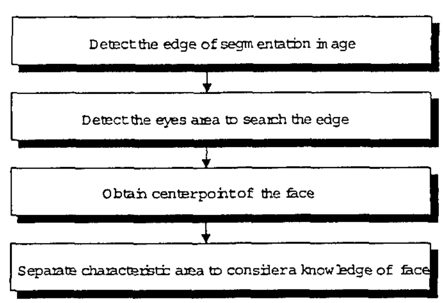


Fig. 2 Flow chart for characteristic detection

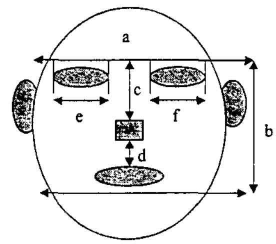


Fig. 3. The normalized distance for characteristic detection.

3. FACE RECOGNITION ALGORITHM BASED ON WAVELET TRANSFORM

This chapter proposes the method of recognizing the face image by using neural network after extracting the characteristics of face in wavelet conversion area. Fig. 4 shows the algorithm flow chart of face recognition. Wavelet is obtained by dilate/translating mother wavelet $\psi(x)$ and it is shown in Expression (2).

$$\Psi_{a,b}(x) = \frac{1}{\sqrt{a}}\Psi\left(\frac{x-b}{a}\right) \tag{2}$$

where, a is scaling parameter, b translation parameter and $\sqrt{}$ a normalization factor. Wavelet conversion Wf(s) of random signal f(x) is defined as convolution integration with original signal f(x) and wavelet ψ (x) as shown in Expression (3).

$$Wf(x) = f * \varphi(x) \tag{3}$$

In addition, when ψ (x,y) = ψ (x)ψ (y) is two-dimensional scaling function in wavelet conversion of two-dimensional function f(x, y) and one-dimensional wavelet with one-dimensional scaling function ψ (x) is ψ (x), two-dimensional wavelets can be explained to separable multi-resolution approximation as shown in Expression (4).

$$\begin{aligned}
\varphi^{A}(x,y) &= \phi(x)\phi(y) \\
\varphi^{V}(x,y) &= \phi(x)\phi(y) \\
\varphi^{H}(x,y) &= \phi(x)\phi(y) \\
\varphi^{D}(x,y) &= \phi(x)\phi(y)
\end{aligned} \tag{4}$$

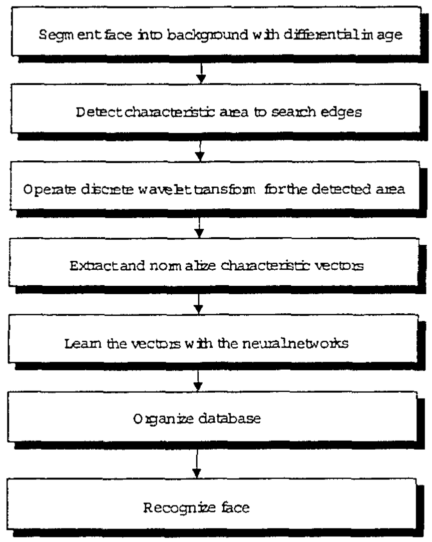


Fig. 4 Flow chart for face recognition algorithm

Two-dimensional signal divided into normal orthogonal distance of Expression (4) is divided into frequency component of spatial direction. The extraction process of feature parameters using wavelet conversion divides two input image signals with resolution of [256×256×28] into characteristic areas with pixel of 91×91 using differential image and edge feature. Then DWT coefficient matrix is obtained with DWT. The following Fig. 5 shows the distribution of coefficient matrix of 4 level DWT, where cA4 means coefficient matrix of 4 level low frequency, cH(i) horizontal high frequency coefficient matrix of (i) level, cV(i) vertical high frequency coefficient matrix of (i) level and cD(i) diagonal high frequency coefficient matrix of (i) level. Feature vectors are extracted by using such coefficient matrixes. When four level DWT of segmented facial characteristic areas is performed, cA4, cH4, cV4 and cD4 which are coefficient matrixes with the size of 6×6 are obtained, where cA4 is four level low frequency coefficient matrix, cH4 horizontal high frequency coefficient matrix, cV4 vertical high frequency coefficient matrix and cD4 diagonal high frequency coefficient matrix, and after analyzing the distribution features of these matrixes, extract feature vectors. First to examine the distribution of coefficient matrix of the same person's learning image, four level DWT is performed with four sample learning images. Then get the absolute values of coefficients of four coefficient matrixes with the size of 6×6, extract 36 feature vectors and normalize them between +1 and -1. Finally after calculating mean square error of normalization vector extracted from cA4, cH4, cV4 and cD4, utilize it as learning vector of neural network based on the size of error.

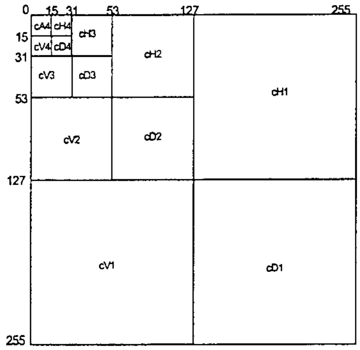


Fig. 5 Four Level DWT Coefficient Matrix

4. SIMULATION

4.1 Face Segmentation and characteristic Detection

This study acquires the input image in the same distance from CCD camera at regular illumination condition with gray scale 256 level of 256×256 and simulation is performed on PC(266MHz). For this, the noise of input image like Fig. 6 and 7 is rejected by using gaussian filter, differential image is obtained and then the face is segmented in background image.

Fig. 6 Input Image(I)

Fig. 7 Input Image (II)

Then the differential image of two input images is obtained. Fig. 8 shows the resulting differential image and Fig. 9 is binary image.

Fig. 8 Differential Image

Fig. 9 Binary Image

Since the differential image cannot be immediately used as mask, it is binary as shown in Fig. 9 and the boundary is reduced. But since the reduction of boundary results in that of face area, the eroded(reduced) image is dilated as shown in Fig. 10. Fig. 11 is mask image generated by examining the pixel value from dilated image.

Fig. 10 Dilated Image   Fig. 11 Mask Image

And mask image is projected on original image with face and the face is segmented in the background as shown in Fig. 12.

Fig. 12 Segmentation Image   Fig. 13 Edge Image

After detecting edge using sobel operator in segmented face image, detect the position of eyes and eyebrow by horizontal distribution of edge components and segment the lower part of eyebrow. Then get the vertical distribution of edge and the center line of face. Finally, the characteristic areas are detected on the basis of the knowledge of human face as shown in Fig. 14.

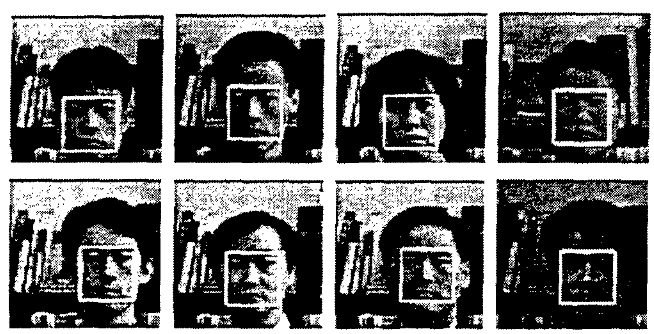


Fig. 14 Facial Characteristic Area

4.2 Face Recognition Experiment

Fig. 15(a)~15(d) are characteristic area separated from four experimental images of the same figure and their size is 91×91 respectively.

(a) (b) (c) (d)

Fig. 15 Example of Separated Characteristic Image

Fig. 16 shows the image of coefficient matrixes of four level wavelet conversion cA4, cH4, cV4 and cD4 and the

information of original image is concentrated on these four coefficient matrixes. The size of these coefficient matrixes is 6 ×6 respectively. For feature extraction, four learning samples of the image in Fig. 15(a)～15(d) are selected, they are converted into four level wavelet and then cA4, cH4, cV4 and cD4 are obtained. Then after analyzing normalization data distribution of the same coefficient matrixes, extract characteristic vector and it is the input vector of neural network by normalizing it between +1 and -1. Fig. 17 shows the distribution condition of normalized characteristic vector. Normalization is performed after taking the absolute value of 6×6 coefficient matrix obtained from four sample images, where horizontal direction is the number of normalized characteristic vectors (36) and vertical direction is the range of normalization between +1 and -1. Error among normalized vectors of the same coefficient matrix is obtained to select input vector of neural network of coefficient matrixes from four sample images like figure 15(a)～15(d). First, RMSE of normalized characteristic vector is obtained in cA4. Then RMSE of cH4, cV4 and cD4 is obtained through the same process. The following Table 1 shows RMSE of each coefficients.

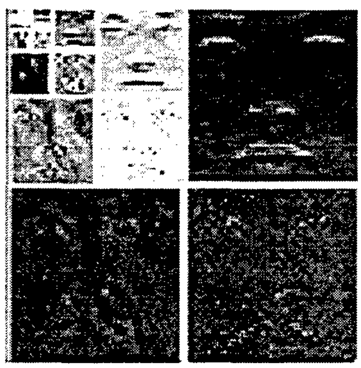


Fig. 16 Four Step Decomposition Image

Total 108 of each 36 from cA4, cH4 and cV4 are extracted as characteristic vectors based on Table 1 and these are the input vectors of neural network. Fig. 18 shows the distribution of 108 neural network input vector extracted from four sample images of the same person.

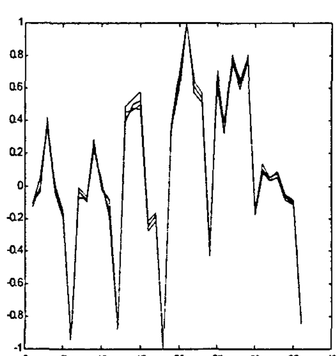


Fig. 17 Normalized Characteristic Vectors

Table 1. RMSE of normalized feature vectors

Class	cA4	cH4	cV4	cD4
RMSE	0.003575	0.004867	0.006381	0.006580

To confirm the validity of characteristic vector extraction, four images of three persons are obtained, wavelet conversion is conducted and the normalized results of coefficient matrix are shown. For this, four sample images of experimental image like Fig. 19(a), 19(b) and 19(c) are selected, four level wavelet conversion of theses images is performed, 6×6 coefficient matrix is normalized and 36 characteristic vectors are extracted. And RMSE among the same coefficients is obtained.

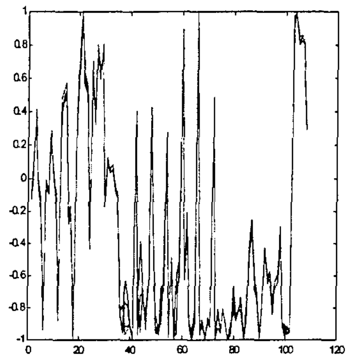


Fig. 18. Extracted Input Vectors

Table 2, 3 and 4 are RMSE of normalized vectors. The largest error is found in normalized vector of cD4.

Table 2. RMSE of normalized feature vectors

Class	cA4	CH4	cV4	cD4
RMSE	0.003076	0.005565	0.003042	0.006726

Table 3. RMSE of normalized feature vectors

Class	cA4	CH4	cV4	cD4
RMSE	0.001788	0.003830	0.002196	0.006224

Table 4. RMSE of normalized feature vectors

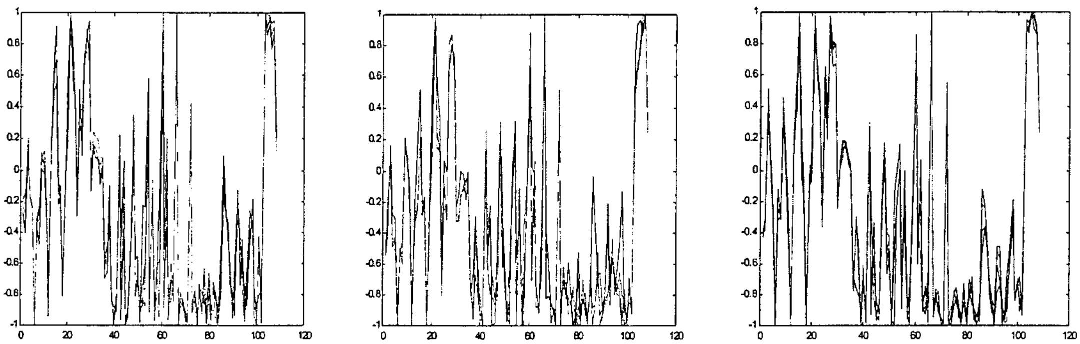
class	cA4	cH4	cV4	CD4
RMSE	0.000848	0.002928	0.001082	0.003476

Fig. 20(a), 20(b) and 20(c) shows the neural network input vector extracted from Fig. 19(a), 19(b) and 19(c).

(a) (b) (c)

Fig. 19 Example of experimental images.

Such 108 normalized input vectors are multi-layer neural network. Learning algorithm of neural network uses error Backpropagation learning algorithm. The error of output layer is 0.005 and learning rate is 0.7. Weight of network generated after learning and feature vector of input comparative image are operated and the recognition is performed by comparing the error of output layer. Then when the error of output layer is less than 0.005, it is judged as the same person.



(a) (b) (c)

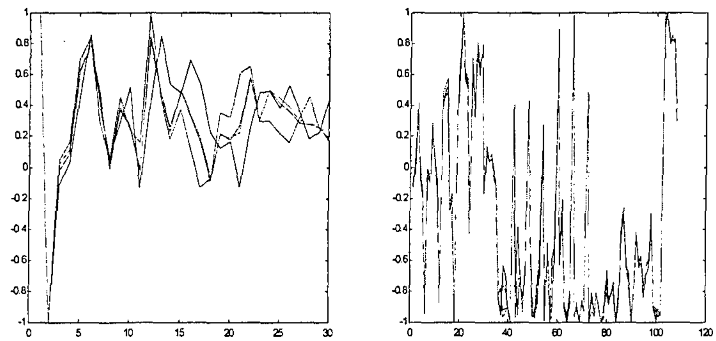
Fig. 20. Extracted input vectors

4.3 Comparison and Examination

The simulation results of proposed algorithms are as follows.

1) Facial image can be segmented 100% in proposed experimental environment by using face segmentation algorithm based on differential image.

2) More elaborate feature vector can be obtained than by using DCT and the recognition rate increases 4%. Fig. 21 shows that the normalization characteristic of feature vectors extracted after wavelet conversion is more evenly distributed than the distribution characteristic of extracted after performing DCT of the same person.



(a) In case of DCT (b) In case of 4 level DWT

Fig. 21 Distribution of Characteristic Vectors

3) Features are extracted by converting the data of spatial area into frequency area and data quantity can be reduced. Also data quantity for operation is reduced by handling characteristic area not the whole face in performing DWT.

4) Since the wrong recognition of included face image occurs, the compensation of inclination is required. And algorithm such as pass word input or fingerprint recognition is required to apply it to perfect complementary system.

5. CONCLUSIONS

We have presented our experiments about face segmentation method based on differential and face recognition using discrete wavelet transform. This algorithm was proposed by following processes. First, two gray-level images was captured with 256 level of the size of 256×256 in constant illumination. W used a Gaussian filter to remove noise of input image and got a differential image between background and input image. Second, a mask was made from erosion and dilation process after binary of the differential image. Third, facial image was divided by projecting the mask into input image. Most characteristic information of human face was in eyebrow, eyes, nose and mouth. In the reason, the facial characteristic were detected after selecting local area including this area. Forth, detecting the characteristic of segmented face image, edge was detected with Sobel operator. Then, eye area and the center of face were searched by using horizontal and vertical components of edge. Characteristic area consists of eyes, a nose, a mouth, eye brows and cheeks, was detected by searching the edge of the image. Finally, characteristic vectors were extracted from performing DWT of this characteristic area and are normalized it between +1 and -1. Normalized vectors was used with input vector of neural network. Through simulation results, we shown recognition rate of 100 % about learned image and 92% about test image.

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